ION IMPLANTING APPARATUS FOR MANUFACTURING SEMICONDUCTOR DEVICES

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0005] The present invention relates to an apparatus for manufacturing semiconductor devices. More particularly, the present invention relates to an ion implanting apparatus for manufacturing semiconductor devices.

2. Description of the Related Art

[0010] In a typical ion implanting process, P-type impurities such as boron (B), aluminum (Al) and indium (In), and N-type impurities such as antimony (Sb), phosphorus (P) and arsenic (As), are used to form a plasma ion beam. A semiconductor wafer is irradiated with the ion beam so that the impurities are implanted into crystalline structures of the wafer to produce desired levels of conductivity and resistivity in the implanted areas. The ion implanting process has widely been used in the manufacturing of semiconductor devices because it allows the concentration of the implanted impurities and hence, the levels of conductivity and resistivity, to be readily controlled.

[0015] The ion implanting apparatus generally includes an ionization unit, an analyzer unit, an acceleration unit, a focusing unit, a scanning unit, an implanting chamber, and a vacuum chamber.

[0020] However, processing defects may be caused by even fine

particles in the ion implantation process. Accordingly, a very significant aspect of the process entails maintaining a high vacuum state within the wafer processing chamber. To this end, a vacuum gauge is used to measure the vacuum levels in the ionization unit, the analyzer unit, and the wafer processing chamber during the ion implanting process. An ionization vacuum gauge is mainly used as such a vacuum gauge. The ionization vacuum gauge measures the flow of positive ions ionized by electron collision (i.e., the gauge measures current). Ionization vacuum gauges may be classified as hot cathode ion gauges (HCIG) and cold cathode ion gauges (CCIG).

[0025] The analyzer unit analyzes positive ions having only a certain atomic weight by employing the operating principle of a mass spectrometer. The analyzer unit has a magnet to establish a magnetic field in proportion to the magnitude of current applied to the analyzer unit. The magnitude of the current is varied based on the type of ion. For example, in the case of boron (B) having an atom weight of "11", current of 28-29A is supplied. In the case of phosphorus (P) having an atomic weight of "31", current of 121-122A is supplied. Accordingly, when the ion to be analyzed is arsenic (As) having an atomic weight of "75", a magnetic field of a very large magnitude is provided.

[0030] The magnetic field established by the magnet of the mass analyzer has an influence on the magnetic field in the cold cathode ion gauge for measuring the vacuum level inside the analyzer unit. If the magnetic field lines are in opposite directions, the cold cathode ion gauge is too unstable to be read correctly. If the magnetic field lines are in the same direction, the

value read by the cold cathode ion gauge fluctuates so widely that the measured vacuum level is utterly unreliable. Furthermore, the superimposed magnetic fields cause the positive ions to deposit rapidly on the negative electrode of the cold cathode ion gauge, thereby reducing the lifespan of the cold cathode ion gauge.

SUMMARY OF THE INVENTION

[0035] An object of the present invention is to provide an ion implanting apparatus and in particular, a vacuum gauge for use therein, that is free of the problems and drawbacks of the prior art.

[0040] More specifically, one object of the present invention is to provide an ion implanting apparatus in which the vacuum level inside an analyzer unit may be measured without being influenced by a magnetic field generated by a magnet of the analyzer unit.

[0045] Another object of the present invention is to provide an ion implanting apparatus in which a large magnetic field may be established in a cold cathode ion gauge and yet the ions are not deposited rapidly onto an electrode of the cold cathode ion gauge, whereby the cold cathode ion gauge retains a long the lifespan.

[0050] To achieve these objects, the present invention provides the combination of a vacuum gauge for use in measuring the level of a vacuum within an analyzer unit of an ion implanting apparatus, and a magnetic field shield for the vacuum gauge.

[0055] According to one aspect of the present invention, an ion

implanting apparatus includes an ionization unit operative to produce an ion beam, an analyzer unit connected to said ionization unit downstream thereof in the apparatus and operative to analyze ions of the beam that are to be implanted into the substrate, a vacuum unit connected to the analyzing unit so as to create a vacuum within the analyzing unit, an implanting chamber connected to the analyzer unit downstream thereof in the apparatus, and the aforementioned vacuum gauge and shield for shielding the vacuum gauge from an external magnetic field such as that generated by a magnet of the analyzer unit.

[0060] The magnetic field shield has a plurality of shielding plates encircling the vacuum gauge, and dielectric material interposed between the shielding plates. Preferably, the shield is a cylindrical member. Also, the shield preferably has three concentric shielding plates.

BRIEF DESCRIPTION OF THE DRAWNGS

[0065] Fig. 1 is a schematic diagram of an ion implanting apparatus according to the present invention.

[0070] FIG. 2 is a perspective view of an analyzer unit of the ion implanting apparatus shown in FIG. 1.

[0075] FIG. 3 is a cross-sectional view of a vacuum gauge according to the present invention.

[0080] FIG. 4 is a perspective view of a magnetic field shield according to the present invention.

[0085] FIG. 5A is a cross-sectional view of an embodiment of the

magnetic field shield, taken along line I-I of FIG. 4.

[0090] FIG. 5B is a cross-sectional view of another embodiment of the magnetic field shield, taken along line I-I of FIG. 4.

[0095] FIG. 6 is a cross-sectional view of a cold cathode ion gauge and the magnetic field shield as coupled to each other.

DETAILED DESCRIPTION FO THE PREFERRED EMBODIMENTS

[0100] An ion implanting apparatus according to the present invention will now be generally described below with reference to Fig. 1.

[0105] The ion implanting apparatus includes an ionization unit 110, an analyzer unit 200, an acceleration unit 120, a focusing unit 130, a scanning unit 140, an implanting chamber 150, and a vacuum pump 160.

[0110] The ionization unit 110 produces ions, and the analyzer unit 200 analyzes ions to be implanted into a wafer from among the ions produced by the ionization unit 110 by employing the operating principle of a mass spectrometer. The analyzer unit 200 will be described in more detail with reference to Fig. 2.

[0115] The analyzer unit 200 is a mass analyzer that defines a tunnel having a small height and width. The central portion of the analyzer unit 200 has a constant radius of curvature, in which the direction of the ion beam is changed. A magnet 220 disposed on the outside of the tunnel causes ions that are unfit for implantation to remain in the tunnel as the ion beam produced by the ionization unit 110 passes through the tunnel. The magnitude of current supplied to the analyzer unit 200 is varied based on the atomic

weight of the ion to be analyzed. That is, the larger the atomic weight of the ion to be analyzed is, the higher is the magnitude of the current supplied to the analyzer unit 200.

[0120] Referring again to Fig. 1, the acceleration unit 120 accelerates the analyzed ions to provide the ions with enough energy to implant them into a wafer to a desired depth. The focusing unit 130 focuses the ion beam to prevent the ion beam from being split apart by repulsive forces exerted by the ions, namely by positive ions that agglomerate when ionized neutral atoms migrate. The scanning unit 140 moves the ion beam up and down and to the left and right so as to distribute the ion beam uniformly over the wafer. The ions are implanted into the wafer within the implanting chamber 150. The vacuum pump 160 maintains a vacuum inside the analyzer unit 200.

[0125] As shown in Fig. 2, a cold cathode ion gauge is disposed at one side of the analyzer unit 200. The cold cathode ion gauge is a vacuum gauge for measuring the level of the vacuum inside the analyzer unit 200. The cold cathode ion gauge will now be described in detail with reference to Fig. 3.

[0130] The cold cathode ion gauge includes a cathode 242, an anode 244, and a permanent magnet 246. The cathode 242 is a cylindrical electrode having one end communicating with the analyzer unit 200. The anode 244 is a cylindrical electrode that is coaxial with the cathode 242 and is inserted into the cathode 242 as spaced a predetermined distance away from an inner wall thereof. A high voltage is applied to the cathode 242 and the anode 244, causing electrons to migrate from the negative electrode to the positive

electrode.

[0135] The permanent magnet 246 is disposed around the cathode 242 so as to establish a magnetic field that is parallel with the longitudinal axes of the electrodes. Due to the magnetic field, the electrons migrate to the positive electrode within a constant orbit, i.e., not in a linear direction. This increases the probability that these electrons collide against gas molecules situated between the cathode 242 and the anode 244, and leads to improvement in production of positive ions. The produced positive ions migrate to the negative electrode, which migration is measured as the magnitude of the current. The pressure within the gauge can be estimated because the magnitude of the current is proportional to the number of gas molecules and the volume of gas is measurable.

[0140] The permanent magnet 246 of the cold cathode ion gauge 240 must establish a magnetic field having a constant magnitude during an ion implanting process. This is because the accuracy of the cold cathode ion gauge 240 is reduced by variations in the magnitude of the magnetic field. However, a very large magnetic field generated by the magnet 220 of the analyzer unit 200 would affect the magnetic field in the cold cathode ion gauge 240. To circumvent this potential problem, the ion implanting apparatus according to the invention has a magnetic field shield 260. Magnetic field shields according to the present invention will now be described with reference to Fig. 4, Fig. 5A and Fig. 5B.

[0145] The magnetic field shield 260 is a tubular member into which the cold cathode ion gauge 240 is inserted. Preferably, the magnetic field shield

260 is cylindrical because a polygonal member may facilitate arcing at the angled intersections of its side walls. The shield 260 has an inner wall 261 and an outer wall 262 which are made of stainless steel.

[0150] The shield 260 may also include a first magnetic field shielding plate 263a and a second magnetic field shielding plate 264a, as shown in FIG. 5A. The first and second magnetic field shielding plates 263a and 264a are cylindrical and coaxial with each other. The first magnetic field shielding plate 263a is attached to the inner wall 261, and the second magnetic field shielding plate 264a is attached to the outer wall 262 such that a predetermined space exists between the first and second magnetic field shielding plates 263a and 264a. A high-k dielectric substance 266 is inserted into the predetermined space in order to enhance the magnetic shielding effect.

[0155] In the embodiment of FIG. 5B, the shield 260 includes a first magnetic field shielding plate 263b attached to the inner wall 261, a second magnetic field shielding plate 264b attached to the outer wall 262, and a third magnetic field shielding plate 265 interposed between the first and second magnetic shielding plate 263b and 264b. Preferably, the third magnetic field shielding plate 265 is disposed midway between the first and second magnetic field shielding plates 263b and 264b. These plates 263b, 264b, and 265 are concentric circle and are spaced apart by predetermined distances. A dielectric substance 266 is inserted into the space between the first and third magnetic field shielding plates 263b and 265 and into the space between the third and second magnetic field shielding plates 265 and

264b. The dielectric substance 266 between the first and third magnetic field shielding plates 263b and 265 may be the same as or different from the dielectric substance 266 between the third and second magnetic field shielding plates 265 and 264b.

[0160] FIG. 6 shows the cold cathode ion gauge 240 and the shield 260 coupled to each other. The shield 260 has an inner diameter that is equal to or larger than the outside diameter of the permanent magnet 246 of the cold cathode ion gauge 240. A stopper 270 is installed in the shield 260 to prevent the shield 260 from falling off of the cold cathode ion gauge 240 when the cold cathode ion gauge 240 is oriented vertically in the apparatus.

[0170] The magnetic field established in the cold cathode ion gauge 240 is always constant because the magnetic field shield 260 extends around the circumference of the cold cathode ion gauge 240. Therefore, the vacuum level inside of the analyzer unit 200 can be precisely measured.

[0175] In the present invention, the magnetic field shield 260 has been described as comprising two or three magnetic field shielding plates. These plates may be made of any material suitable for offering a shield against a magnetic field. Moreover, any number of magnetic field shielding plates may employed by the shield 260 - the greater the number of magnetic field shielding plates there are, the less the magnetic field generated by the magnet of the analyzer will influence the reading of the cold cathode ion gauge.

[0180] Finally, although the present invention has been described with respect to the preferred embodiments thereof, various modifications as will

occur to those skilled in the art can be made to the preferred embodiments without departing from the true spirit and scope of the invention as defined by the appended claims.